Entergy

Entergy Nuclear Northeast
Indian Point Energy Center
295 Broadway, Suite 1
P.O. Box 249
Buchanan, NY 10511-0249
Tel 914 734 5340
Fax 914 734 5718

Fred Dacimo
Vice President, Operations

June 12, 2003
NL-03-098

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Stop O-P1-17
Washington, D.C. 20555-0001

SUBJECT: Indian Point Nuclear Generating Unit No. 3
Docket 50-286
Reactor Vessel Head Inspection Results;
Indian Point 3, Spring 2003 Refueling Outage

References:
1. NRC Order EA-03-009, "Issuance of Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors", dated February 11, 2003.
2. ENO letter to NRC, IPN-02-095, "Reactor Pressure Vessel Head and Penetration Nozzles Inspection Plan for Spring 2003 Refueling Outage", dated December 19, 2002.
3. Entergy letter to NRC, NL-03-037; "Answer to February 11, 2003 Order", dated March 3, 2003.

Dear Sir:

This letter provides the Reactor Vessel Head Inspection Report (Attachment I) for Indian Point 3, in accordance with Section IV. E of NRC Order EA-03-009 (Reference 1). The inspection was performed during refueling outage 3R12 that was completed on April 23, 2003.

The inspection consisted of a bare metal visual examination, which satisfies the requirements of Section IV.C (2)(a) of the Order, based on the Moderate Category as defined in Section IV.B of the Order. In addition, Entergy Nuclear Operations, Inc (ENO) performed supplemental ultrasonic and eddy current examinations on approximately one-half of the reactor vessel head penetration nozzles. Although these inspections were not necessary to comply with the requirements of the Order, the inspection plan established by ENO (Reference 2), in response to Bulletins that preceded the Order, contained provisions for supplemental inspections. ENO confirmed, in the consent to the Order (Reference 3) the intent to perform inspections based on the plan described in Reference 2.

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Based on the results of these inspections, ENO concludes that there are no indications of reactor pressure vessel head degradation or primary water stress corrosion cracking of the Alloy 600 penetration nozzles.

No new commitments are being made in this letter. If you have any questions, please contact Mr. John McCann (914) 734-5074, Licensing Manager.

Very truly yours,

Fred R. Dacimo
Vice President, Operations
Indian Point Energy Center

cc: Mr. Hubert J. Miller
Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406-1415

Mr. Patrick Milano, Senior Project Manager
Project Directorate I-1
Division of Licensing Project Management
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Mail Stop 0-8-C2
Washington, DC 20555-0001

U.S. Nuclear Regulatory Commission
Resident Inspectors' Office
Indian Point 2 Nuclear Power Plant
P.O. Box 38
Buchanan, NY 10511

U.S. Nuclear Regulatory Commission
Resident Inspectors' Office
Indian Point 3 Nuclear Power Plant
P.O. Box 337
Buchanan, NY 10511

ATTACHMENT I TO NL-03-098

REACTOR VESSEL HEAD INSPECTION RESULTS; INDIAN POINT 3, SPRING 2003 REFUELING OUTAGE

ENTERGY NUCLEAR OPERATIONS, INC
INDIAN POINT NUCLEAR GENERATING UNIT NO. 3
DOCKET NO. 50-286

Introduction

Entergy Nuclear Operations, Inc (ENO) performed an inspection of the Indian Point 3 (IP3) reactor pressure vessel (RPV) head and vessel head penetration (VHP) nozzles in April 2003, during refueling outage 3R12. The inspection complied with NRC Order EA-03-009 (Reference 1). Prior to issuance of the NRC Order, ENO had developed an inspection plan (Reference 2) in response to NRC Bulletins that were in effect prior to the Order. The ENO response to the Order (Reference 3) confirmed that the proposed inspection plan also met the requirements of the Order.

Based on the EDY (effective degradation years) methodology and criteria stated in Sections IV.A and IV.B of the Order, ENO determined that the IP3 RPV head was in the moderate susceptibility category for the inspection to be conducted in 3R12 (Reference 4). Section IV.C(2) of the Order specifies an inspection based on either bare metal visual examination of the RPV head surface or non-destructive examination techniques (ultrasonic or eddy current) applied to the vessel head penetration nozzles. The inspection performed at IP3 consisted of bare metal visual examination of 100% of the RPV head surface, which satisfies the option specified in Section IV.C (2)(a) of the Order. Prior to conducting the visual examination, the existing permanently installed RPV head insulation had to be removed. Following completion of the inspection activities, a new insulation design was installed which will support improved accessibility for future inspections. In addition to the bare metal visual examination, ENO performed supplemental non-destructive examination of approximately half of the VHP nozzles, consistent with the plan described in Reference 2.

Based on these inspections, ENO concludes that there are no signs of reactor pressure vessel head degradation or primary water stress corrosion cracking of the Alloy 600 penetration nozzles. Additional details regarding the inspections are provided in the following sections.

Bare Metal Visual (BMV) Examinations

The remote BMV examination included the entire top surface of the vessel head inside the control rod drive mechanism (CRDM) cooling shroud support ring and 360-degrees around each of the individual penetrations in the vessel head, consistent with EPRI and MRP guidance provided in References 5 and 6. The BMV examination was conducted using a remote system equipped with:

1) A low profile robotic crawler with traction devices;
2) High-resolution cameras (front and side);
3) Air interrogation attachment; and
4) A video probe delivery system.

The remote examination system provided visual resolution equivalent to a direct VT-2 visual examination.

The original IP3 reactor vessel head insulation consisted of "Kaylo Block", covered with asbestos tape and asbestos cement. The "Kaylo Block" rested directly on and followed the contour of the vessel head surface. Since the insulation configuration prevented an effective BMV, the original insulation was removed prior to performing the inspection. The insulation removal crew was instructed to exercise caution during the removal of the insulation so as not to wipe off, smear or disturb any boron deposits that may be present on the surface of the vessel head. The purpose of these instructions was to prevent the inadvertent removal of any boron evidence around the nozzles prior to the BMV examination, which could indicate the presence of leakage initiated at the J-groove weld region.

Some debris was observed on the side of VHP nozzle 72, but there were no boron deposits found in the nozzle area indicative of through-wall nozzle leaks originating from within the RPV head base material. Samples of the debris were taken for chemical / isotopic analysis. ENO concluded that the debris is insulation material, possibly with some old boron deposits from earlier identified leaks which originated from above the reactor vessel head. A history of the leaks from the canopy seals above the reactor vessel head in the same area, was previously submitted in a response to Bulletin 2001-01. The chemical / isotopic analysis of the age of the deposits is consistent with the historical data.

Following removal of the insulation, an effective BMV examination of the head surface was performed, remaining debris was removed, and a new reflective insulation system, offset from the head surface, was installed to allow for future BMV inspections of the head.

Personnel Qualification

Personnel who performed the remote examination were VT-2 Level II or Level III visual examiners, in accordance with the requirements of ASME Section XI, 1989 Edition or later approved code editions. The BMV examiners also received a familiarization pre-job training using photographs of industry examination results from References 5 and 6, and from inspection tapes from the IP2 BMV examination in the Fall, 2002. An Entergy Level III visual examiner also reviewed the inspection results and findings summarized in the BMV inspection report (Reference 7).

Supplemental NDE Examinations

In addition to the BMV described above, Entergy also performed some supplemental NDE examinations of the VHP nozzles, as proposed in Reference 2. The supplemental NDE inspections were performed by qualified personnel from WesDyne, a division of the Westinghouse Corporation, under the supervision of ENO personnel.

The inside surface of the CRDM tube was inspected with a combination of volumetric (i.e., ultrasonic, UT) and surface (i.e., eddy current, ECT) examination techniques using a single probe arrangement. The examination covered sufficient axial length of the tube to span at least 2 inches above the J-groove weld to the lowest position achievable on the bottom of the nozzle. Prior to the outage, ENO had submitted a relaxation request (Reference 8) regarding limitations on UT of the bottom 0.75 inches of the nozzle, which is threaded for the CRDM guide funnels. During this inspection, ENO was able to obtain meaningful ECT data down to the top of the lead-in-chamfer region, located approximately 0.25 inches from the bottom of the nozzle. The relaxation request was not required for this inspection, because full compliance with the Order was achieved based on the BMV inspection. However, experience gained during this outage can be used to support approval of the relaxation request for future inspections.

Qualification (Demonstration) of Equipment, Personnel and Procedures:

A demonstration of the WesDyne inspection equipment and procedures was conducted at their Windsor, CT facility during the period of August 26 to September 11, 2002. Open-tube and blade-probe UT and ECT equipment and the specific WesDyne procedures for the inspection of the VHP tube and weld-to-tube interface from the inside surface of the tube were demonstrated. The demonstration was conducted using the Entergy / EPRI / MRP mock-up samples, as part of the readiness review process established by the MRP demonstration protocol (i.e., a blind demonstration testing for the relevant procedures and essential variables) (Reference 9). The essential variables relevant to the inspection procedures for UT and ECT data acquisition are as specified in the appropriate sections of the procedures (References 10 through 14). These essential variables were presented in the MRP demonstration, which was also witnessed by NRC staff. EPRI has reviewed these procedures for essential variables and no deficiencies were noted during their review.

Comments from WesDyne, EPRI, NRC and Entergy representatives who attended the demonstration were addressed during the demonstration process. Necessary changes and/or improvements were subsequently incorporated into applicable WesDyne NDE procedures for the IP3 VHP inspection.

WestDyne personnel associated with either data acquisition or analysis received additional specialized training for the appropriate skills. There are no specific pass/fail criteria at this time since there is no formalized qualification program beyond the MRP demonstrations.

Personnel performing data acquisition or data analysis were certified Level II or Level III, in accordance with ASNT, SNT-TC-1A, 1984 Edition requirements. Entergy personnel provided continuous oversight during the VHP inspection project and reviewed both the eddy current and ultrasonic data analysis results.

Ultrasonic examinations (UT) using time-of-flight diffraction (TOFD) techniques were used to interrogate the thickness of the CRDM VHPs and approximately 0.1 inches of the attachment J-weld thickness. The primary transducers were axially oriented, 5 or 6 MHz pairs, with a probe center spacing (PCS) of 24mm. A supplemental Eddy Current (ECT) coil accompanied the UT transducers to provide an examination of the inside surface for each of the open housings, part length nozzles and thermal sleeved CRDM VHPs that were inspected.

Probe delivery for CRDM VHPs with thermal sleeves and part lengths, was a saber / blade probe - gap scanner designed to fit between the thermal sleeve and VHP inside surface. CRDM VHPs without a thermal sleeve were examined using a 7010 open housing scanner. Both scanners were mounted on a DERI 700 multi-purpose manipulator used to position the scanner below the VHP being examined.

Ultrasonic testing of interference fit samples for leak path detection was also used at selected nozzles. This testing was performed on VHP nozzles 1, 2, 3, and 5, which, based on analysis, (Reference 15) maintain tight circumferential closure at the bottom of the interference zone, thereby preventing a potential leakage path to the outer surface of the vessel head.

The theoretical basis for leak path detection is the change in the reflection coefficient at the nozzle to head interface. This difference (Reference 14) in reflection amplitude between an interference fit and gap was measured at approximately 1 db (or 10% of signal amplitude). This effect is relative; the absolute value of the backwall reflection is a function of several parameters such as insertion loss, surface condition and grain structure.

As an example, in VHP nozzle 5, there were two bands with substantially different backwall amplitudes. The ECT test shows that the inner diameter surface is mottled in one region and smooth in the other, which is the likely cause for the backwall amplitude differences. These two regions were analyzed separately to evaluate whether a leak path existed by analyzing for a relative amplitude change of 10% of the nominal backwall amplitude for that region. No leak path indication was detected in either region.

It is also important to note that in the counterbore region, which is nominally 0.003 inches larger in diameter, there can still be an interference fit due to machining tolerances and thermal distortion of the nozzle.

<u>Criteria used for determining if "shadowing" should be called a flaw</u>:

Typically when evaluating the NDE data, the loss of "backwall" coupled with "shadowing" of the background material noise shall be called an OD flaw > 0.5" deep (Reference 14).

<u>The UT/ET inspection coverage and results are summarized as follows</u>:

41 of the total 78 nozzles (52.6% of all CRDM penetrations) were inspected using UT and further examined by the ECT method. The remaining 37 of 78 total nozzles were not scanned by either UT or ECT because of equipment access limitations and equipment malfunctions. Major access limitations included: variations in the nozzle-to-thermal sleeve gaps, and presence of centering tabs on the OD side of the penetration, which are located in close proximity to the weld, interfering with inspection. Most of the inspected nozzles received a 100% inspection while only 3 received partial coverage as noted below. No cracking was detected in any of these 41 nozzles inspected.

- All open-housing nozzles (18 total), all part length nozzles (7 total), and 13 thermal-sleeved nozzles were 100% scanned with the combined UT / ECT probe.

- 3 thermal-sleeved nozzles (scanned by UT/ECT) received partial coverage. These are: nozzle 6 (90%); nozzle 65 (91%); and nozzle 66 (83%).

- The axial coverage of all inspected CRDM tubes (41) extended from at least 2 inches above the J-groove weld to the lowest position achievable on the bottom of the nozzle (i.e., to less than 0.75 inches from the bottom of the nozzle by UT, and to the top of the lead-in-chamfer region, approximately 0.25 inches from the bottom of the nozzle by ECT.

- All 4 nozzles which, based on analysis, maintain tight circumferential closure (nozzles 1, 2, 3, and 5) received further assessment of the interference fit zone. Only nozzle 1 received partial coverage (260°).

- The inspection covered a cross section sampling of nozzles, from center to peripheral nozzles, including nozzle 77 that was fabricated from a heat of material with high yield strength. Peripheral nozzles are normally subjected to the highest weld residual stresses.

Because of difficulties encountered during the NDE phase of the inspection, the original planned inspection duration was extended to maximize scanning of the remaining nozzles with challenging physical geometries. Also, ENO used the additional time to conduct a gauging program to better understand the impact of the physical limitations experienced in the thermal sleeve-to-penetration tube geometry. The data from the gauging program will be used to develop a future inspection program to help complete scanning of the remaining nozzles.

Corrective Actions and Root Cause Determination

Based on the results of the 100% BMV examinations there were no indications of degradation of the VHPs or wastage of the vessel head base metal surface. The supplemental NDE examinations of the VHP nozzles and the adjacent J-groove welds also confirmed there were no defects which would be indicative of PWSCC of the Alloy 600 material. Therefore, no corrective actions or root cause determinations were deemed necessary.

Upon completion of the BMV examinations, the remaining debris on the reactor vessel head (adjacent to Penetration 72) was removed and a newly designed reflective insulation system, which is offset from the head surface, was installed to allow for future visual inspection of the head.

References

1. NRC letter dated February 11, 2003; S. Collins to Holders of Licenses for Operating Pressurized Water Reactors, "Issuance of Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors".

2. ENO letter to NRC, IPN-02-095, "Reactor Pressure Vessel Head and Penetration Nozzles Inspection Plan for Spring 2003 Refueling Outage", dated December 19, 2002.

3. ENO letter to NRC, NL-03-037, "Answer to February 11, 2003 Order to Modify PWR Licenses for Interim Inspection Requirements for Reactor Pressure Vessel Heads", dated March 3, 2003.

4. Calculation No. IP3-CALC-RV-03720, Rev. 0, "Estimation of Effective Degradation years (EDY) by March 28, 2003 for IP3 Reactor Vessel Head".

5. EPRI Report 1006296, Rev. 1; "Visual Examination for Leakage of PWR Reactor Head Penetrations", January 2002.

6. EPRI Report 1007337, Rev. 1; "PWR Reactor Pressure Vessel (RPV) Upper Head Penetrations Inspection Plan, September 2002.

7. IP3 Report, "VT-2 System Leakage Test" of the Indian Point 3 Reactor Vessel Head, dated April 12, 2003.

8. ENO letter to NRC, NL-03-054, "NRC Order EA-03-009 Relaxation Request Regarding Inspection of Reactor Pressure Vessel Head Nozzles", dated March 27, 2003.

9. MRP Interim Status Report on PVHP Inspection Performance Demonstration Activities, November 1, 2002.

10. Procedure No. WDI-ET-003, Rev. 4, "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations", and one "Procedure Field Change Request", March, 2003.

11. Procedure No. WDI-ET-004, Rev. 2, "IntraSpect Eddy Current Analysis Guidelines Inspection of Reactor Vessel Head Penetrations", as modified by Procedure Field Change Request(s).

12. Procedure No. WDI-ET-008, Rev. 1, "IntraSpect Eddy Current Imaging Procedure for Inspection of Reactor Vessel Head Penetrations with Gap Scanner", as modified by Procedure Field Change Request(s).

13. Procedure No. WDI-UT-010, Rev. 4, "IntraSpect Ultrasonic Procedure for Inspection of Reactor Vessel Head Penetrations, Time of Flight Ultrasonic, Longitudinal Wave & Shear Wave", as modified by Procedure Field Change Request(s).

14. Procedure No. WDI-UT-013, Rev. 2, "CRDM/ICI UT Analysis Guidelines", as modified by Procedure Field Change Request(s).

15. Calculation No. IP3-CALC-RV-03787, Rev. 0, "IP3-Updated Leak Path Determination for Closure Head CRDM Penetrations 1 and 4 for IP3 Using Finite Element Analysis, dated March 27, 2003.